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A FIELD EVALUATION OF THE CYCLONE SEEDER
FOR REDUCING RICHARDSON GROUND SQUIRREL POPULATIONS
CAUSING DAMAGE IN CENTRAL MONTANA

By

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ABSTRACT

The total cost of control and the time (bait plus manhours) required to hand bait large acreages infested with Richardson ground squirrels in central Montana prompted this evaluation of the cyclone seeder as an alternative baiting method. Strychnine grain bait applied in 20-foot swaths at 20-foot intervals reduced ground squirrels by 97% for the 10 lb/swath-acre application rate and 90% for the 6 lb/swath-acre application rate. On all of the strip applications, the total cost of control and the time required per acre treated was less than by the hand baiting method. Using the 6 lb/swath-acre rate at 20-foot intervals, the total cost per acre was 57% of what was required for hand baiting, and more than 5 times the amount of acreage could be treated in the same amount of time.

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INTRODUCTION

The Richardson ground squirrel (Spermophilus richardsoni) poses a serious pest problem in many areas of central Montana by competing in pasture and rangeland areas with livestock for forage, and also causes serious damage to hay and grain crops. Estimates derived from a 1973 Rodent Questionnaire (Seyler, 1973) indicated Richardson ground squirrels accounted for \$4,708,710 of damage in 27 Montana counties. It is necessary to manage Richardson ground squirrel populations in order to reduce and minimize economic damage.

At rodent control planning meetings and training demonstrations conducted in Park County, Montana during the spring of 1977, landowners expressed dissatisfaction of hand baiting for controlling large infestations of Richardson ground squirrels. Landowners reported that while hand baiting with strychnine grain bait was effective for reducing ground squirrels, the method was too slow and expensive to be practical for treating large acreages. The Park County Commissioners and Rodent Control Board requested the Montana Department of Livestock to investigate alternative methods for reducing Richardson ground squirrel infestations.

Strychnine grain bait, registered by the U.S. Environmental Protection Agency for use in Montana, is approved for broadcast application by the cyclone seeder for pine, deer, and meadow mouse control. The only method registered for applying grain bait for the control of Richardson ground squirrels in Montana is by hand. Grain bait application by hand is expensive in terms of bait cost and required man-hours, and does not always provide satisfactory population reduction in large areas of high squirrel densities.

OBJECTIVES

Field evaluations were conducted in Park County in June 1977 to determine the efficacy and economic feasibility of the cyclone seeder

as an alternative to hand baiting for reducing Richardson ground squirrel infestations. Hazards to non-target species were also assessed.

METHODS AND MATERIALS

Study Area

Nine sites were selected for evaluation. Sites 1 through 5 (Figure 1), located three miles east of Wilsall, Montana on the Howard Keyes ranch, were in rolling, dryland hills and had been seeded to grass and alfalfa. Sites 6 through 9 (Figure 2), located five miles north of Wilsall on the Carl Arthun ranch, were in grass-sagebrush rangeland.

Site acreage varied from 2.3 to 20.5 acres (Table 1), depending upon numbers of ground squirrels present and geographical boundaries. Sites were separated by a natural barrier or a buffer area of at least 600 feet to minimize the possibility of one squirrel's home range encompassing more than one site. The size of the buffer area was chosen to equal twice the diameter of the maximum home range of Richardson ground squirrels as recorded by Clark (1970).

Percent of vegetation coverage and bare ground were estimated by visual observation methods described by DeVos and Mosby, 1971 (Table 1).

Cyclone Seeder Calibration

The cyclone seeder was mounted on the front bumper of a Willys CJ5 Jeep. Vehicle speed was maintained at 5 mph during both the calibration and bait application.

A narrow swath width of 20 feet was selected because a uniform bait distribution was achieved across the entire swath. Swath profiles

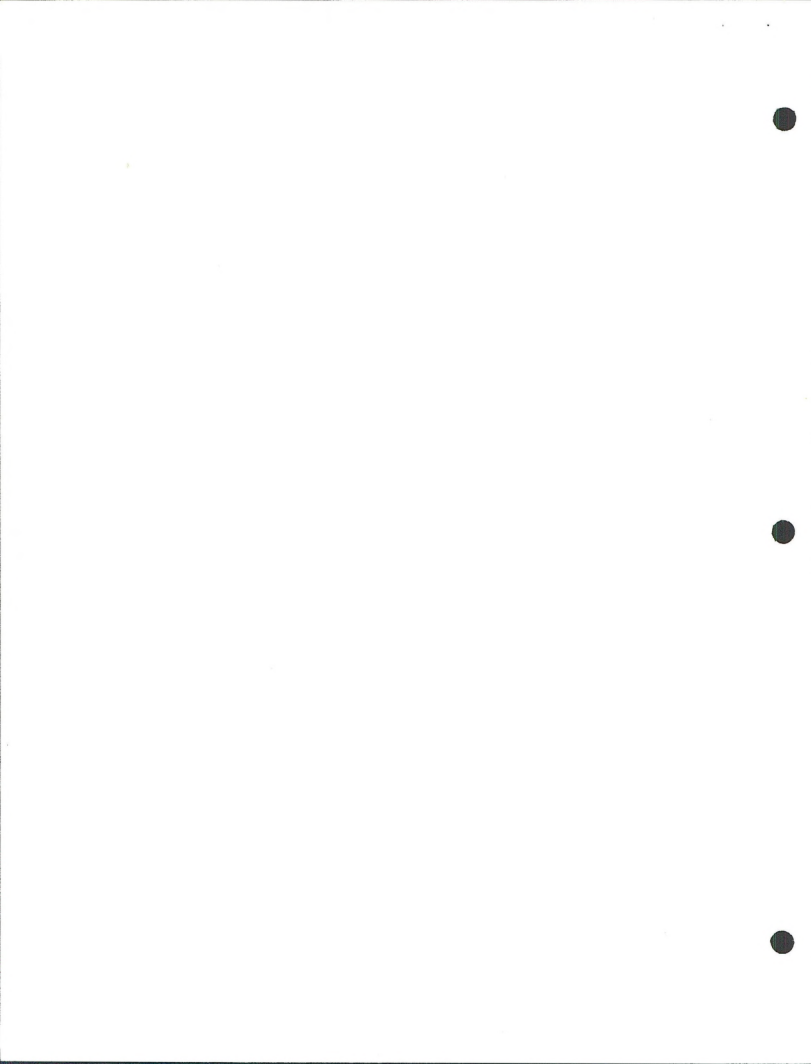
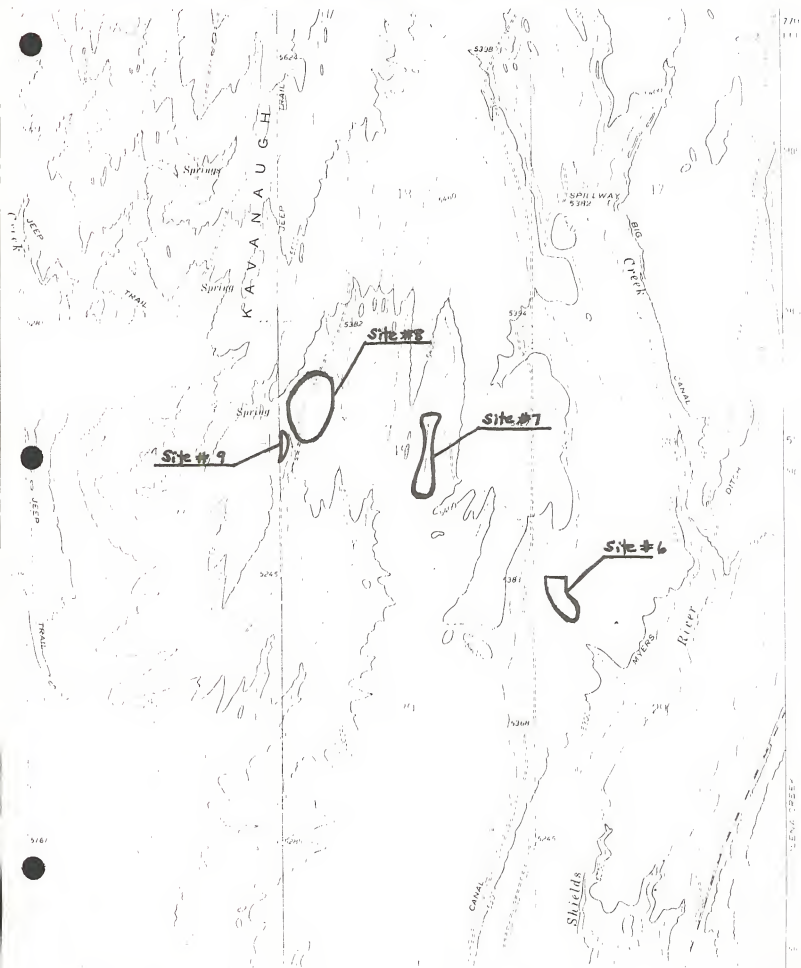


Figure 2: Study Sites 6-9, Arthun Ranch (USGS Topographic Map, Cottonwood Reservoir Quadrangle, Scale 1:24000).



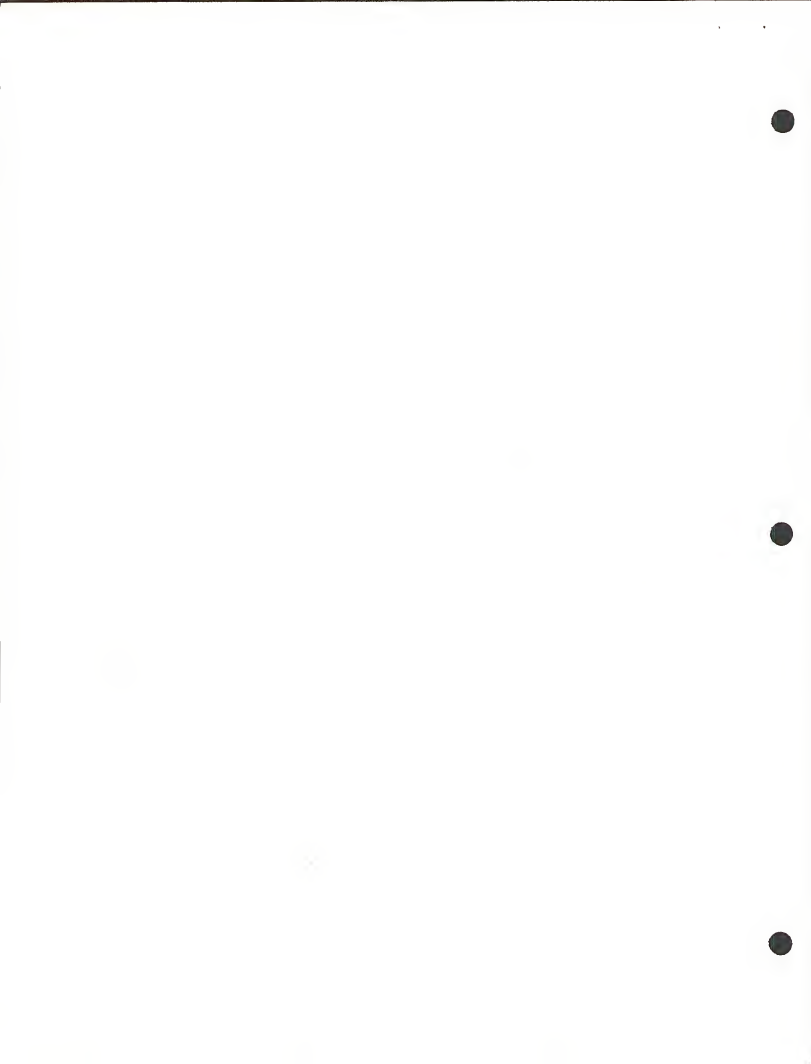
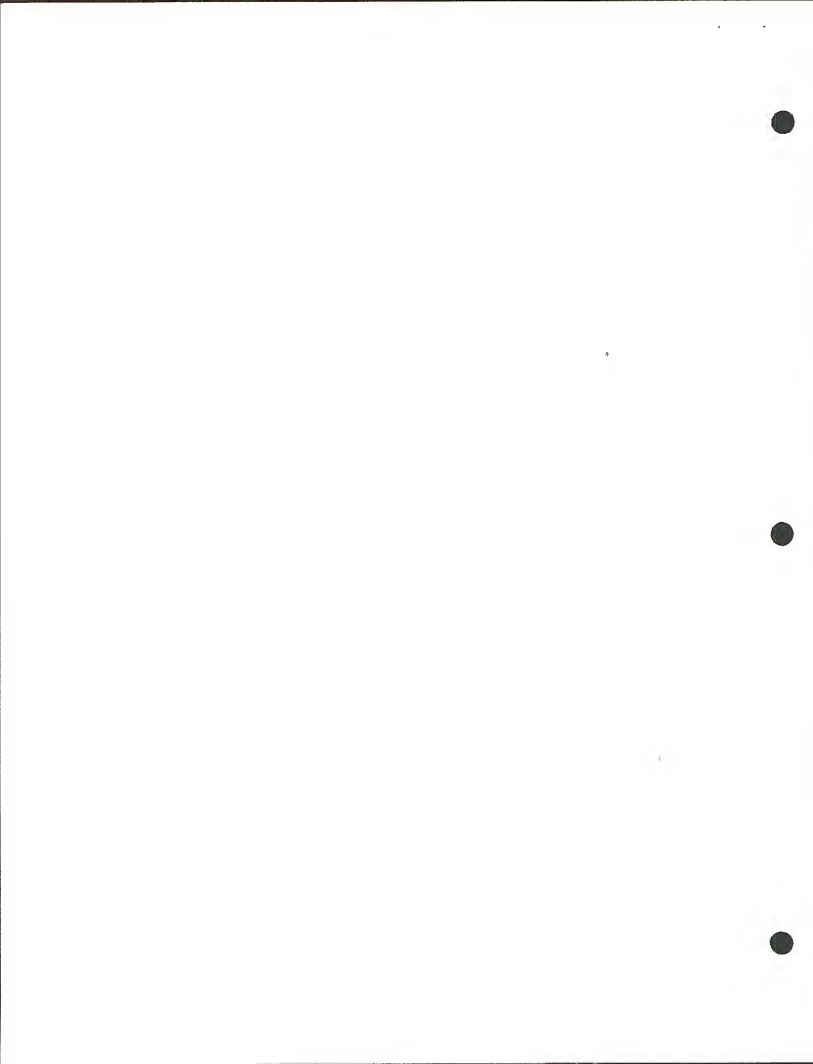


Table 1: Description of Study Sites: Size, Vegetation Coverage, and Bare Ground

<u>Site</u>	<u>Area (Acres)</u>	<u>Percent Vegetation Coverage and Plant Classes¹</u>	<u>Percent Bare Ground</u>
1	14.4	75% -- Alfalfa, Grasses	25%
2	17.5	35% -- Alfalfa, Big Sagebrush, Thistle	65%
3	20.2	50% -- Alfalfa, Grasses	50%
4	4.8	80% -- Grass, Alfalfa	20%
5	18.7	70% -- Alfalfa, Grasses, Forbs	30%
6	5.3	95% -- Alfalfa, Grasses	5%
7	11.9	95% -- Grass, Big Sagebrush	5%
8	20.5	75% -- Grass, Big Sagebrush	25%
9	2.3	95% -- Grass, Alfalfa	5%

¹Plant classes are listed in order of abundance.



were determined following the procedures outlined by Marsh (1967). Figure 3 shows the average profile of bait deposited for seven swaths each 20 feet wide. Marsh (1967) found bait deposits to be denser at mid-swath, with density tapering off at the swath extremities when using aircraft. This pattern was not detected with swaths of 20 feet using the cyclone seeder.

Two methods (modified after Marsh, 1967) were used to calibrate the cyclone seeder. The first method required the average number of kernels of grain deposited per square foot be determined for 3, 6, and 10 lb. application rates. The second method involved placing a weighed amount of grain in the cyclone seeder. With the cyclone seeder gate pre-adjusted to the opening determined by Method 1, the vehicle was driven at 5 mph for a distance of 2178 feet.¹ Residual grain in the seeder was weighed to determine the amount applied. Pounds per swath-acre were calculated. If these calculations differed from the desired 3, 6, or 10 lb. rates per swath-acre, the cyclone seeder was re-adjusted and trials run repeatedly until the proper rates were achieved.

Bait Application and Efficacy for Reducing Target Species

Two methods of bait application with the cyclone seeder were evaluated: (1) stripping in parallel swaths across the squirrel-infested area; (2) broadcasting bait uniformly over the entire infested area.

Two bait densities (6 and 10 lbs/swath-acre) were each tested by stripping at intervals of 20 and 100 feet between swaths. Flagmen were used to maintain the desired swath intervals. Six and -----

¹Swath-acre - one acre defined as a strip 20 ft. wide and 2,178 ft. long

3 lbs/swath-acre were each tested by the broadcast method. These bait application rates were chosen in order not to exceed the 6 to 10 lb. bait/acre application rates registered by E.P.A. for use in the cyclone seeder for pine, deer, and meadow mouse control.

The Keyes Ranch (Sites 1, 2, 3, and 5) was chosen for strip application, and the Arthun Ranch (Site 6 and 8) was chosen for broadcasting (Figures 1 and 2). Each site was assigned a particular treatment by random selection.

Sites 4 and 9 were selected as non-treatment areas, one on each of the two ranches. Site 7 was chosen for hand bait application. Hand baiting was done according to label instructions by scattering one calibrated dipper of bait (0.22 ounces) near the entrance to each active ground squirrel burrow. Sebesta¹ strychnine (0.44%) on whole oats dyed with analine yellow was used on each treatment area.

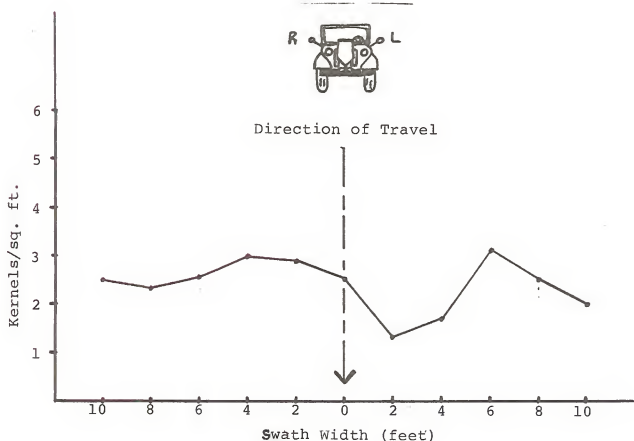
The degree of squirrel reduction was evaluated for each site on the basis of repeated visual squirrel counts before and after treatment (Marsh, 1967; Record, 1976). Squirrel activity counts were conducted three times daily from the same vantage point each day on three consecutive days pre- and post-treatment. Visual censusing was conducted at the same time each day during peak activity periods. The average of all daily counts provided the pre- and post-treatment activity indices at each site.

Residual Bait Assessment

Eight days after treatment, residual bait was measured on each site with a counting frame divided into 9 one-foot squares. On strip application sites the frame was randomly placed in seven

¹Sebesta Bait Mixing Plant, P.O. Box 306, Mitchell, South Dakota

Figure 3. Average profile¹ of bait distribution by the cyclone seeder.



¹The bait distribution profile for the cyclone seeder is an average of seven swaths each 20 feet wide using the 6 lbs/swath-acre application rate. Six lbs/swath-acre using Sebesta whole oats will yield 2.4 kernels per square foot.

different locations on the broadcast application sites. Residual bait on the hand baiting site was determined by counting residual kernels at 31 randomly selected squirrel burrows. The average amount of bait remaining at each burrow entrance was calculated.

Non-target Species Hazard

Observations of non-target species were recorded during pre- and post-treatment activity counts and whenever investigators were visiting a test site. Post-treatment searches were conducted on all test sites and surrounding areas. On the first day after treatment, sites of the heaviest bait application (10 lb. strip and 6 lb. broadcast) were searched by the investigators walking in parallel paths approximately 10 feet apart. Eight days after treatment, all sites were searched by the investigators riding trail bikes in parallel paths approximately 10 feet apart. Low altitude fixed-wing aircraft searches were made over and within a radius of three miles of each test site 8 days post-treatment. The carcasses of all non-target species were sent to the Department of Livestock Diagnostic Laboratory, Bozeman, Montana, for autopsy.

RESULTS

Efficacy for Reducing Target Species

On Sites 2, 5, and 7 the reduction in ground squirrel activity was 97%, 90%, and 94% respectively. Sites 3 and 8 approached the 90% reduction level, with 88% and 87% respectively. Activity reduction on Sites 1 and 6 was 73% and 63% respectively (Table 2).

Greater than 95% population reduction was considered excellent, 90-95% reduction was considered good, and below 90% was considered unsatisfactory by Marsh (1967). A minimum 90% reduction is considered

essential for adequate control. If reduction is much less than 90% a ground squirrel population may return to or exceed its original level within one reproductive season (Marsh, 1967; Record, 1976).

Residual Bait

Residual bait measured on each treatment site eight days following bait application ranged from 25% for the 6 lbs/acre broadcast site to 70% for the 3 lbs/acre broadcast site (Table 3). While the percentage of residual bait seemed to vary substantially with little correlation to the bait application, both the 100-foot strip applications showed less residual bait than did the same application rates for the 20-foot strips.

Concentration of residual bait revealed the hand baiting method left an average of 61.3 kernels of grain per burrow entrance with a range from 0 to 88 kernels/square foot. This compared to all of the cyclone seeder application sites which averaged 1.0 kernels/square foot and ranged from 0 to 5 kernels/square foot.

Non-Target Species Hazard

The following non-target species were observed on or near one or all of the treatment sites both pre- and post-treatment: red winged blackbird (Agelaius phoeniceus), sparrows (Ammodramus bairdii and Melospiza melodia), robin (Turdus migratorius), western meadowlark (Sturnella neglecta), killdeer (Charadrius vociferus), horned lark (Eremophila alpestris), common pigeon (Columba livia), crow (Corvus brachyrhynchos), magpie (Pica pica), barn swallow (Hirundo rustica), sage grouse (Centrocercus urophasianus), common snipe (Capella gallinago), sandhill crane (Grus canadensis), prairie falcon (Falco mexicanus), ferruginous hawk (Buteo regalis), Swainson's hawk (Buteo swainsonii),

Table 2. Percent reduction in ground squirrel activity

<u>Site</u>	<u>Method of Application</u>	<u>Bait Density by Application Rate</u>	<u>Percent Reduction</u>
1	Strip (100) ¹	10 lbs/swath-acre	73%
2	Strip (20)	10 lbs/swath-acre	97%
3	Strip (100)	6 lbs/swath-acre	88%
4	Non-treatment		29%
5	Strip (20)	6 lbs/swath-acre	90%
6	Broadcast	6 lbs/acre	63% ²
7	Hand Bait	0.22 oz/burrow	94%
8	Broadcast	3 lbs/acre	87%
9	Non-treatment		0%

¹() - interval between swaths (in feet).

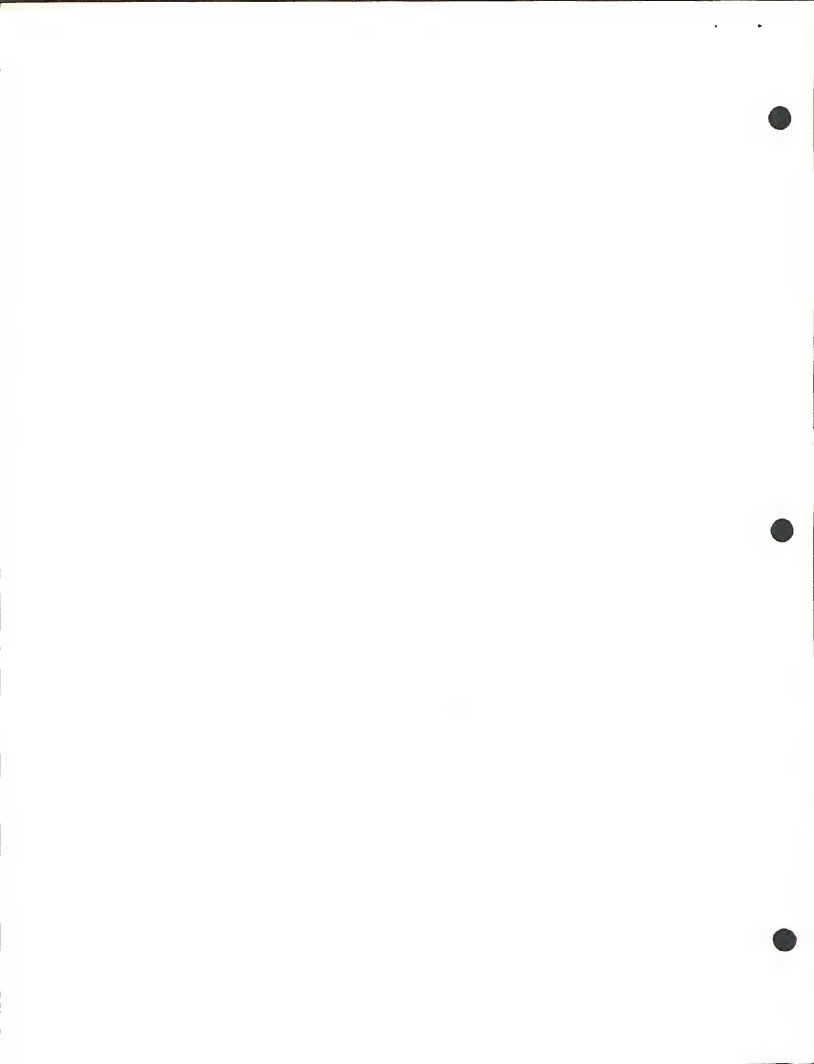
²Flood irrigation may have accounted for low reduction.



Table 3. Residual Bait at each treatment site eight days post-treatment.

<u>Site</u>	<u>Method of Application</u>	<u>Bait Density by Application Rate</u>	<u>Bait Density Based Upon Total Gross Treatment Acreage (lbs/acre)</u>		<u>Residual Bait, % of Initial Application</u>
			<u>Applied</u>	<u>Residual</u>	
1	Strip (100) ¹	10 lbs/swath-acre	1.67	.52	31%
2	Strip (20)	10 lbs/swath-acre	5.00	2.62	52%
3	Strip (100)	6 lbs/swath-acre	1.04	.40	38%
4	Non-treatment				
5	Strip (20)	6 lbs/swath-acre	3.02	1.92	64%
6	Broadcast	6 lbs/acre	5.66	1.44	25%
7	Hand Bait	1 calibrated dipper (0.22 oz.)/burrow	3.78	1.12	30%
8	Broadcast	3 lbs/acre	3.00	2.09	70%
9	Non-treatment				

¹ () - interval in feet between swaths



golden eagle (Aquila chrysaetos), mule deer (Odocoileus hemionus), and long-tail weasel (Mustela frenata). Badger holes were found on all treatment sites except Site 6.

After treatment crows, magpies, and golden eagles were observed daily feeding on poisoned ground squirrel carcasses. During the air searches conducted after treatment, no dead carnivores or birds were found.

Carcasses of three non-target species were found during the intensive post-treatment ground searches. A western meadowlark and a common pigeon were found on the cyclone seeder broadcast application Sites 6 and 8, respectively. Both birds were diagnosed positive for strychnine poisoning. A deer mouse (Peromyscus sp.) was found on the hand baited Site #7. The laboratory report on the mouse was inconclusive about the cause of death.

DISCUSSION

Analysis of the efficacy and economics of the cyclone seeder as compared to hand baiting (Table 4) shows that only the 10 lbs/swath-acre application rate stripped on at 20-foot intervals has a greater ground squirrel reduction (97% vs. 94%) and a lower total cost per acre (\$3.68 vs. \$3.94). Although these differences are not great, further consideration of the time required to treat one acre by each method shows that with the cyclone seeder (0.17 manhours/acre) nearly 3.5 times the acreage could be treated as compared to hand baiting (0.59 manhours/acre) in the same amount of time. These results need further clarification before conclusions may be reached.

The results obtained by the cyclone seeder on Site #2 (Table 4) may have been influenced by the relatively light vegetation cover (35% coverage) found there. The principle of baiting by the cyclone

seeder is once toxic bait is placed through an infested area, ground squirrels normally foraging in the same area will locate and consume a lethal dose. The ground squirrel's ability to locate a lethal dose of bait is dependent upon several factors, two of which are the density of toxic grain applied and the density of vegetation on the ground. Vegetative cover not only provides a natural food supply for these rodents, but also tends to conceal the toxic grain. While the 10 lbs/swath-acre application rate stripped on at 20-foot intervals worked well in light vegetation, the same application rate stripped on at 100-foot intervals reduced ground squirrels by only 73% when the vegetation cover was 75%. This seems to suggest that intervals between strip applications need to be reduced in heavy vegetative cover, while in light vegetation they might be increased. The 6 lbs/swath-acre application rates produced encouraging results, but neither stripping at 20-foot intervals (90% reduction), nor stripping at 100-foot intervals (88% reduction) exceeded the efficacy achieved by hand baiting (94% reduction). Both applications were made in relatively moderate vegetation (Table 4) and economically, each shows a substantial savings over hand baiting. Further, it is likely that following the 3 days of post-treatment squirrel counts, additional squirrels would be likely to consume some of the residual bait, thereby improving results which were obtained. It should be noted while these application rates approached results obtained by hand baiting but did not exceed them, the net pounds of bait applied per acre was less for each than by hand baiting.

The time required to treat an acre reveals the 6 lbs/swath-acre application rate stripped on at 20-foot intervals (0.11 manhours/acre) can treat over 5 times the acreage done by hand in the same amount of

Table 4. Economic and efficacy analysis of the cyclone seeder compared with hand baiting.

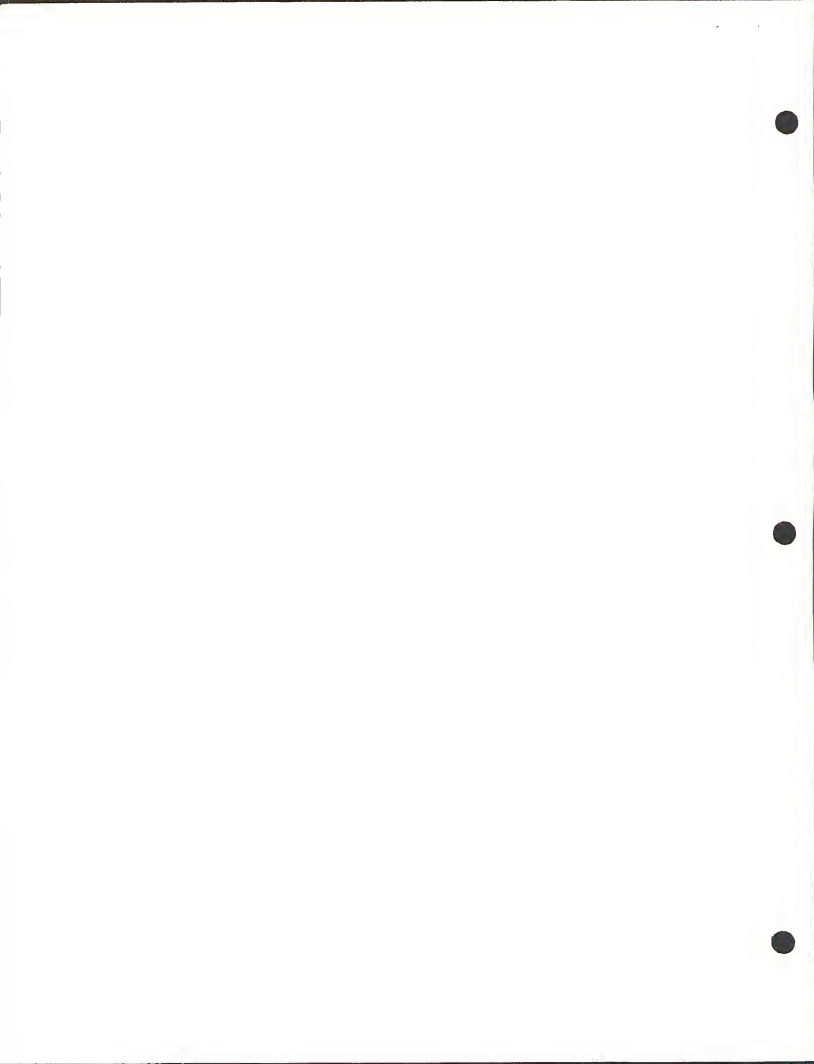
Site	Method of Application	Bait Density by Application Rate	Percent Vegetation Coverage	Acres Treated	Net lbs. Bait/Acre	Man-Hours ¹ Per Acre	Bait ² Cost/Acre	Man-Hours ³ Cost/Acre	Total Cost/Acre	Percent Ground Squirrel Reduction
1	Strip (100) ⁴	10 lbs/swath-acre	75%	14.4	1.7	.12	\$1.08	\$.30	\$1.38	73%
2	Strip (20)	10 lbs/swath-acre	35%	17.5	5.0	.17	3.25	.43	3.68	97%
3	Strip (100)	6 lbs/swath-acre	50%	20.2	1.0	.07	.68	.18	.86	88%
4	Non-treatment									
5	Strip (20)	6 lbs/swath-acre	70%	18.7	3.0	.11	1.96	.28	2.24	90%
6	Broadcast	6 lbs/acre	95%	5.3	5.7	.32	3.68	.80	4.48	63%
7	Hand Bait	0.22 oz/entrance	95%	11.9	3.8	.59	2.46	1.48	3.94	94%
8	Broadcast	3 lbs/acre	75%	20.5	3.0	.24	1.95	.60	2.55	87%
9	Non-Treatment									

¹Based on 3 persons, except on Site #7 where it is based on 4 persons.

²Bait cost based on \$0.65/lb.

³Man-hour cost based on a wage of \$2.50/hr.

⁴() - interval in feet between swaths.



time. By comparison, the 6 lb. rate stripped at 100-foot intervals (0.07 manhours/acre) can cover over 8 times the acreage in the same amount of time as could be done by hand (0.59 manhours/acre).

The 3 lbs/acre application rate which was broadcast uniformly over the infested area produced similar results to those obtained by the 6 lbs/swath-acre stripped on at 20-foot intervals. Each used the same net pounds of bait per acre (3 lbs.). Efficacy was recorded at 87% reduction of ground squirrels where the vegetative cover was estimated at 75%. Cost of the 3 lbs. broadcast method was slightly higher than the strip method because of increased manhours per acre which were required. This cost (\$2.55/acre) was still considerably less than hand baiting (\$3.94/acre).

The heaviest application rate, 6 lbs/acre broadcast method (Site #6) showed inconsistent results with those obtained by the cyclone seeder on other study sites. Site #6 had a 95% vegetation coverage, which by previous discussion would probably have required a greater amount of bait to achieve good efficacy results. However, this site was disrupted during the study when an adjacent pasture was flood irrigated for four consecutive days, beginning the day prior to treatment. Some irrigation water flowed onto the study site. While some squirrels on the study site were displaced by the water, additional squirrels evacuating their burrows in the adjacent pasture may have moved onto the study site. Finally, there was evidence some shooting of squirrels had taken place during the investigation period. Consequently, the poor reduction of ground squirrels on this site (63%) may have been due to factors other than the dense vegetative cover.

Residual bait on the areas treated with the cyclone seeder ranged

from 25% to 70% after eight days (Table 3). Thirty percent of the original bait remained after 8 days on the hand baited area. Similar results were found in California, when Marsh (1967) recorded that 39%, 40%, and 62% of the original aerially applied bait remained after eight days. Marsh noted that no residual bait was found following the winter season.

Examination of ten poisoned squirrel carcasses observed to have been fed upon by eagles indicated the digestive tracts were avoided. The squirrels had been eviscerated and the muscle portions consumed. Crows and magpies also eviscerated carcasses which were fed upon. On Site #5 one day after treatment, an estimated 90% of the squirrel carcasses had been eaten. The digestive tract was lying adjacent to the carcass remains in nearly every instance. Observations of eagles feeding upon ground squirrel carcasses revealed that either the eagles were not eating the digestive tracts, or if the eagles were consuming the digestive tracts (none observed) they did not consume a lethal dose of strychnine from the poisoned squirrels. No dead eagles or other avian scavengers were found during intensive post-treatment searches.

Since strychnine grain bait is registered by the U. S. Environmental Protection Agency and approved for broadcast application by the cyclone seeder for pine, deer, and meadow mouse control, no effort was made to assess the impact of the cyclone seeder on these and other small rodent species. It is significant, however, that less bait than is required and approved for mouse control (broadcast at 6 to 10 lbs/acre) is necessary for reducing ground squirrels (Table 4 - see Net Pounds Bait/Acre). It was further assumed baiting with the cyclone seeder would present only minimal hazard to livestock because of the

light bait density over the treated areas. No livestock losses were observed during or reported after this investigation.

Baiting with the cyclone seeder has advantages over hand baiting. Fewer people are required for the cyclone seeder baiting operation. A vehicle operator and one flagger are essential. Use of the cyclone seeder eliminates the need for large baiting crews. Although infestations of Richardson ground squirrels may be controlled by hand baiting where manpower costs make hand baiting impractical, these areas can be treated by the cyclone seeder in less time with reduced cost. Only those areas with steep hillsides or extremely rough terrain cannot be treated with the cyclone seeder because of their unsuitability for vehicle travel.

While the cyclone seeder application method is dependent upon the ground squirrel's foraging habits and the vegetative cover, certain times of the year may provide better results. When the ground squirrels are breeding in early spring, before the vegetation has turned green, baiting by the cyclone seeder may produce good results. This time would also be appropriate to alleviate the problem before the damage occurs. After the young are weaned, during mid-summer when the vegetation is drying, would also be a good time to implement control operations.

CONCLUSIONS

1. The cyclone seeder is efficacious in reducing Richardson ground squirrel populations.
2. The efficacy of reducing ground squirrels using the cyclone seeder may be dependent upon vegetation characteristics.
3. The man-hours and time required are significantly reduced when using the cyclone seeder as compared to hand baiting.

4. The total cost of control per acre is less for the cyclone seeder methods than by hand baiting, with the exception of the 6 lbs/acre broadcast application.
5. The results of post-treatment searches indicate the use of the cyclone seeder had a negligible effect on non-target species.
6. Bait application rates for Richardson ground squirrel control by the cyclone seeder need not exceed the minimum application rate (6 lbs/acre) approved for use by the U. S. Environmental Protection Agency for pine, deer, and meadow mouse control.

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